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MINISTRY OF TECHNOLOGY

AEROPLANE AND ARMAMENT EXPERIMENTAL ESTABLISHMENT

BOSCOMBE DOWN

WESSEX HC 2 XM 834

ENGINE HANDLING AND PROPULSION ROTOR SPEED GOVERNOR PERFORMANCE

PRESENTED BY

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AEROPLANE AND ARMAMENT EXPERIMENTAL ESTABLISHMENT
BOSCOMBE DOWN

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(6) Wessex Mk. 3 XM 834
(Gazelle Mk. 165)

Engine Handling and Production Rotor Speed Governor Performance (U),

Presented by

E. M. Evans, Performance Division and G. W. Smith, MBE, RAF Flying Division

A&AEE Ref: APF/106/05
Period of Trials: January to March, 1967

Summary

Tests have been carried out on a production Wessex Mk. 3 XM 834, mainly to evaluate the characteristics of the production rotor speed governor and with particular reference to increased production tolerances in the system.

The results were satisfactory although datum shifts were experienced due to temperature, and governor and throttle control hysteresis effects. It is considered that these effects would not cause undue difficulty in controlling the engine and rotor, but some recommendations are made with a view to improving the governing system.

This report is issued with the authority of

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/1. Introduction

1. Introduction

The difference in tolerance of production and development rotor speed governors in the Wessex Mk. 3 helicopter necessitated a brief engine handling trial with particular emphasis on governor behaviour in various conditions of flight. The type of governor has been described in previous reports (e.g. Ref. 1) and in principle controls the speed of the free (power) turbine by means of fuel spill. It has limited authority and its functioning is indicated to the pilot by a 'Null' position indicator on the instrument panel. With the needle at the 'Zero' position, which corresponds to 22½% fuel spill from the delivery to the burners, the rotor speed is governed at about 227 rpm. From this position extreme indications are given by:-

3 divisions to left	-	no fuel spill
8 divisions to right	-	maximum spill of 45% fuel flow

A diagrammatic layout of the system is contained in Fig. 1.

During the tests, a new engine change unit was fitted, which was of benefit to the trial in that it provided a comparison between two engine/governor installations and enabled a method of initial governor adjustment and 'Null' indicator calibration to be agreed upon (Appendix I).

2. Conditions relative to tests

2.1 Description of aircraft

XM 834 was a standard production Wessex Mk. 3 helicopter fitted with a Gazelle Mk. 165 engine. For the first two sorties engine No. GA 632 was fitted and for the remainder of the trial engine No. GA 3008. No special instrumentation was fitted as it was considered that flight test observer readings of the cockpit gauges corrected for instrument error were acceptable.

2.2 Date, time and place

The trial consisted of seven sorties totalling 6 hours 55 minutes and was conducted at A&AEE Boscombe Down between January and March 1967.

2.3 Weight and C of G

The helicopter was flown at a take-off weight of 13,500 lb. with the C of G in the mid position. The C of G position was not considered critical in relation to engine handling.

2.4 Limitations

The helicopter was flown to the current CA release and Aircrew Notes (advanced issue). The following relevant engine and rotor limitations are quoted for ease of reference.

/2.4.1

2.4.1 Engine

Power rating	Time limit	rpm		Max. jpt °C	Max. Torque psi≠
		Compressor	Free turbine rotor equivalent		
1 hour	1 hour	19,600 (Max.)*	239	615	440
Max. continuous	-	19,100 (Max.,	239	580	395
Flight idling	-	13,500	239	-	-
Ground idling	-	11,000 ± 250	-	570	-
Starting	-	-	-	570	-

*19,900 transiently for not more than 10 seconds during rapid engine acceleration.

≠This is torque meter reading - for simplicity torque is given in terms of psi reading rather than the true lb. ft. unit.

2.4.2 Rotor

Power On	rpm
Nominal setting	227
Maximum transient	205 to 258
Power Off	
Autorotation	215 to 245
Maximum transient	190 to 258

2.5 Weather

Weather conditions during the trial were good and air temperatures were normal for the time of the year. When considered relevant, temperatures are quoted or shown on the curves plotted.

3. Method of test

The tests were conducted as follows:-

3.1 Engine starting and governor engagement.

3.2 Governor performance in the following steady state conditions:-

3.2.1 Take-off and hover.

3.2.2 Climb at 60 knots IAS and 400 psi torque to 10,000 feet.

/3.2.3

3.2.3 Level flight at 10,000 feet through the permissible speed range.

3.2.4 Flight idle descent from 10,000 feet.

3.2.5 Level flight through the speed range at 2,000 feet.

3.2.6 Vertical flight at varying power up to maximum permissible torque.

3.2.7 Engine response during recovery from autorotation at 1,000 feet.

3.3 Powered flight recovery from ground idle descent.

3.4 Manual throttle handling with governor disengaged.

3.5 Re-engaging the governor in flight.

4. Results of tests

4.1 Engine starting and governor engagement

The majority of engine starts were made using an external source of power and no difficulty was encountered. Governor engagements were made using the method quoted in the flight reference cards, i.e., with the governor range lever on its forward stop, the twist grip on the collective control was rotated open to give 225 rotor rpm with a 'Null' position indication within one division of full left. A hesitation in compressor acceleration was observed as the 'Null' needle moved from the full left position, confirming that the governor half ball valve had lifted off the spill orifice and the system was functioning. The above method of engagement was initially recommended by the Aircraft Firm.

The method of governor engagement recommended by the Engine Firm in their operating instructions was also investigated as a comparison with the above.

This method was carried out as follows:-

The governor range lever was fully to the rear of the gate (i.e. emergency manual condition with governor inoperative.

The twist grip was opened to give 227-232 rotor rpm.

The governor range lever was advanced to its forward stop.

The position of 'Null' indication was checked to ensure that the indication had moved away from the extreme left position showing that the governor was in operation and with a consequent small drop in rotor speed.

This was checked to ensure that rpm were between 222 and 226.

It was found to be somewhat easier and quicker to achieve the required governor datum by using the method in the flight reference cards rather than the Engine Firm's method, as the setting of 227-232 rotor rpm took time to achieve because of the sensitivity of the throttle in manual control, and an

/additional

additional control movement was required in selecting the governor range lever forward. The setting up procedure laid down in the flight reference cards was used for all recorded tests and after setting up, for the majority of governor tests, friction was applied to the twist grip throttle and thereafter the control was undisturbed throughout flight. Some specific tests were also made using the twist grip (para. 4.3 and 4.4).

The table in Appendix II gives the results (engine parameters and 'Null' indications) obtained during test sorties and other sorties made during the period of trials. It can be seen that governor datum shifts apparently occurred during flight. Whilst the variation in rotor rpm and 'Null' position recorded at the beginning and end of each sortie for hover conditions was insignificant there was a noticeable tendency for the rotor rpm to settle at a lower value on landing at the end of the sortie than when originally set up on the ground before take-off. The maximum deterioration in rotor speed recorded was 2 rpm (i.e. from 225 to 223 rpm). In addition, Appendix II shows variation in the 'Null' indication for no fuel spill at the beginning and end of each sortie. The maximum variation recorded was 0.7 of a division (i.e. from 2.3 left at take-off to 3 left after landing).

4.2 Rotor governor performance

4.2.1 Take-off and hover

During the initial part of the take-off when raising the collective control from the fully down position (approximately 100 psi torque) to a position equivalent to 200 psi torque, the rotor rpm tended to decrease below the basic setting of 225 rpm, then quickly recovered as the control was raised further, settling at approximately 227 rpm in the hover at approximately 350 psi torque. On all observed take-offs the lowest rotor speed reached was 222 rpm. No handling problems were encountered as a result of this characteristic. This condition was not apparent on the second engine tested (GA 3008) but it was very evident with the first engine (GA 632). Other Wessex Mk. 3 helicopters flown at A&AEE and the Firms have also confirmed the above variations in rotor speed.

4.2.2 Climb at 60 knots IAS and 400 psi torque to 10,000 feet

Fig. 2 shows the plot of the climb to 10,000 feet at 400 psi torque at 60 knots IAS (engine No. GA 632). It can be seen that when maintainin constant torque, by increasing rotor pitch there was a decrease in rotor speed starting at a height of about 4,000 feet. The movement of the governor 'Null' indicator to compensate for this decrease was very small. At 7,000 feet there was a more rapid decrease in rotor rpm, but at this altitude the compressor reached its limiting speed of 19,600 rpm and the collective control had to be lowered a small amount to reduce the compressor rpm. Fig. 3 shows plots of a similar sortie with the second engine (GA 3008). Again during the climb, the fall off in rotor rpm was evident at 4,000 and 7,000 feet with little compensation registering on the governor 'Null' indicator.

4.2.3 Level flight through the permissible speed range at 10,000 feet

Figs. 4(a) and (b) show plots of levels through the speed range at 10,000 feet with engine No. GA 632 and GA 3008 respectively. Good governing was achieved in both instances. The increase in compressor speed and power required in Fig. 3(b) was due to the increased all-up-weight during that sortie.

/4.2.4

4.2.4 Flight idle descent from 10,000 feet

Figs. 5 and 6 show plots of flight idle descents from 10,000 feet (engine No. GA 632 and GA 3008 respectively). It can be seen from Fig. 5 that in steady state conditions with free-wheel disengaged (needles split) at 10,000 feet the governor was at the limit of its authority, i.e. 'Null' indication 8 divisions to the right (full fuel bleed by the governor). There appeared to be no transient follow-up of the power turbine when lowering the collective lever at normal rates to achieve the flight idle condition. Rapid entries to auto-rotation were not investigated at altitude. In Fig. 6 the 'Null' indicator was at 6 divisions right leaving two divisions in hand which was equivalent to 5½% fuel bleed in hand. In both descents, the free turbine was well controlled at approximately 232 (equivalent rotor rpm) which was well below the maximum limit of 239 rpm.

4.2.5 Level flight through the speed range at 2,000 feet

Figs. 7(a) and (b) show plots of flight through the speed range at 2,000 feet with the two engines GA 632 and GA 3008. Governing was good and results consistent.

4.2.6 Flight and ground test at varying power up to maximum permissible torque

Fig. 8 shows a plot of ground and flight tests at varying power up to maximum torque of 440 psi. These tests were made on engine No. GA 3008 and entailed pulling increments of 50 psi torque from the minimum collective pitch position on ground (which gave approximately 100 psi torque) up to maximum permissible torque. Good governing is seen, which was within the production clearance tolerance recommended by the Firm. No significant static rotor "droop" was evident below 200 psi torque with this engine as has been evident on other production aircraft, and also in particular on some tests made with No. GA 632 (see para. 4.2.1).

4.2.7 Engine response during recovery from autorotation at 1,000 feet

The engine response to power demand from autorotation at 60 knots IAS was good and the transient rotor "droop" low. Power was demanded to 420 psi torque (steady state) from a low collective lever position giving an auto-rotative condition where the rotor and free power turbine rpm needles were just joined; the results in terms of the transient torques and rotor rpm for different collective pitch application times are shown below. Power was demanded at 1,000 feet with a 'Null' indication of 1½-2 divisions right (prior to applying collective pitch).

Collective Control Time of Application	"Transient" rotor rpm	"Transient" torque
3.2 secs.	222 rpm	435 psi
3.2 secs.	221 rpm	445 psi
2.3 secs.	221 rpm	440 psi

/4.3

4.3 Powered flight recovery from ground idle descent

As the technique for practice autorotative landings laid down in the Wessex Mk. 3 Aircrew Notes (Part III, Chapter 2 paragraph 19(b)) includes the removal of the flight idle stop and rotating the twist grip closed to ground idle, it was considered desirable to investigate briefly the handling implications of recovery to powered flight in the event of a baulked landing from this condition.

Prior to flight, engine acceleration checks were made on the ground with the rotor turning and power turbine and rotor needles joined (free wheel engaged). Commencing with the twist grip fully closed at ground idle (11,300 compressor rpm at 115 rotor rpm) the twist grip was opened rapidly by a small amount and the time taken for the compressor to accelerate from 11,300 rpm through 13,500 rpm was measured (13,500 compressor rpm datum was used as this is the normal flight idle compressor speed above which acceleration is known to be good). The average time of three tests was 1.5 seconds.

In flight, three autorotative descents were made commencing at 1,500 feet with the flight idle stop out, the governor range lever forward, the rotor alternator switched off and the twist grip closed against the stop. This simulated the condition prior to making a practice autorotative landing. In three descents the following figures were recorded:-

Compressor rpm	Null indicator position	Rotor rpm	Free power turbine rpm (rotor equivalent)	OAT °C
11,250	1.5 divisions right	240	180	+9

At approximately 800 feet, a recovery to powered flight was made by applying collective pitch to reduce rotor speed to 227 rpm and then opening the twist grip to engage the free-wheel (needles joined). This was followed immediately by raising the collective control to recover powered flight.

If this was done without care, it was possible to bring about a harsh engagement of the free wheel, because of the uneven acceleration of the compressor with twist grip movement. When the twist grip was opened, the compressor accelerated relatively slowly (due to the acceleration control unit) up to approximately 13,000 rpm and thereafter very rapidly. This in turn tended to cause an uneven acceleration of the free turbine. After the free-wheel was engaged (needles joined) a rapid application of power could be made without much difficulty because, although some adjustment of the twist grip was necessary, rotor rpm was also being controlled by the governor.

The minimum height lost during the recovery to powered flight without making a harsh free-wheel engagement was about 100 feet.

4.4 Manual throttle handling with governor disengaged

A qualitative assessment of manual throttle handling was carried out by making 'take-offs' to the hover, vertical climbs, circuits, transitions back to the hover and landings, with the governor disengaged (i.e. governor range lever in the fully aft position). This aspect had been previously

/examined

examined in more detail in Wessex XG 255 during June 1965 (Ref. 2). The current assessment indicated that the throttle/collective control synchronisation was similar in characteristics to that found in XG 255 i.e. when raising the control above a position corresponding to 200 psi torque, it was necessary to reduce power with the twist grip to maintain rotor rpm and vice versa when lowering the control. It was however considered to be slightly more difficult to control rotor rpm on this aircraft than XG 255 and during circuits using normal concentration, the rotor speed varied from the intended 225 rpm by ± 5 rpm. The greatest variation of rotor rpm took place when demanding power during a transition to the hover.

4.5 Re-engaging the governor in flight

After flying with the governor disengaged, it was re-engaged in flight by using the method quoted in Wessex Mk. 3 Aircrew Notes (advanced issue). This was achieved by cruising at 80 knots IAS in level flight and advancing the governor range lever to its fully forward position, and at the same time adjusting the twist grip to maintain rotor rpm. Final adjustment was made by opening the twist grip to give 228 rotor rpm and checking that the 'Null' indicator position was between 'Null' and one division right.

This setting up procedure was considered to be most satisfactory particularly as it was tied to a speed and flight condition. After landing, the 'Null' position and rotor rpm indications (i.e. within one division of full left and 223-225 rpm respectively) proved that the twist grip position achieved was very close to that set up with the governor engaged prior to take-off. This in-flight engagement was carried out successfully on three separate occasions.

4.6 Governor runaway

No particular tests were made during the present trials but following recommendations made in Ref. 2 the Firm investigated faults in the governing system which could cause governor runaway; the results are contained in the Firm's report reference T/FB/ER/1,670 dated 27th May, 1966. It was considered that the possibility of a system failure causing this condition was extremely remote but an emergency drill following a runaway up or down will be contained in Pilot's Notes for the Wessex Mk. 3.

5. Discussion of Results and Conclusions

5.1 Engine starting and governor engagement

No problems were encountered during starting throughout the trial. The method of setting up the governor quoted in the flight reference cards was considered to be easier and quicker than the method proposed by the engine firm. In addition, the former method was based on setting a fixed datum rotor speed (i.e. 225 rpm) compared with accepting a variable rotor speed of 222 to 226 rpm in the latter. As rotor speed is of primary importance to the pilot, it is considered more desirable to set up a fixed rotor speed and accept a variation in governor 'Null' position than setting to a tight 'Null' position and accepting a variation in rotor rpm. The variation in rotor rpm/'Null' position between the beginning and the end of each sortie, and particularly the drop in rotor rpm after landing is considered to be due to hysteresis effects in the governor coupled with

/a

a 'Null' indicator datum shift. This latter effect was apparently due to temperature effects on materials in the governor and indicator system. In-flight datum shifts can also occur with collective pitch control movements and subsequent throttle linkage hysteresis. Whilst it is doubtful if much can be done to improve the throttle linkage to eliminate throttle hysteresis, it is understood that the Engine Firm are attempting to reduce hysteresis effect in the governor by quality control during production. They also have a scheme for modifying the materials in the governor and its indication system to eliminate the temperature effect.

If it is necessary to take-off again after a landing with the rotor rpm probably at a lower value than originally set, the original rotor rpm datum will be substantially regained during the later stages of the take-off. Some variation on 'Null' indication position is likely compared with the original setting up due to the temperature effect on the system (previously referred to) causing the indication for full bleed to move further to the left. If it is desired to re-set the governor on the ground after landing, the original datum can only be regained (less temperature effects) by first closing the twist grip to the point where the governor is out of authority and then re-setting. This should eliminate the effect of governor hysteresis.

On one occasion during the trial sorties it was necessary to accept a 'Null' position indication slightly in excess of one division from full left. As it is known that tolerances in production governors are such that the present limitations on 'Null' indication cannot always be met, and that the initial ground engagement setting effects the in-flight readings, it is considered that the Aircraft and Engine Firm should review both initial setting and in-flight limits with a view to extending them. For ease of reference, the limits at present quoted in aircrew notes and flight reference cards are as follows:-

Flight reference cards

Card No. 7 — Engaging the governor after starting

Re-adjust the throttle to give 225 rotor rpm. Check that the governor 'Null' indication moves off its stop and is within one division of full left.

Card No. 9 — Check after take-off that governor 'Null' indication is within ± 1 division of Zero.

Card No. 11 — Approach phase. Check governor 'Null' indication is within ± 1 divisions of Zero.

Card No. 24 — Governor malfunction

Rotor rpm outside 223-232 in steady state. 'Null' indication exceeds 1 divisions left or 3 divisions right in level flight.

Governor malfunction check

At 80 knots IAS adjust throttle twist grip to give 227 rpm. Check 'Null' indication is between Zero and 1 division right.

/Aircrew

Aircrew Notes (advanced issue)

Part 3, chapter 2, paragraph 7(b)	Take-off and hover
	Rotor rpm 227 ± 1, 'Null' indicator within 1 division left to 1 division right.
Part 3, chapter 2, paragraph 15(c)	Selecting governor in during flight
	At 80 knots IAS in level flight, adjust the throttle twist grip to give 228 rotor rpm. Check 'Null' indicator is between Zero and 1 division right.
Part 3, chapter 2, paragraph 15(d)	Governor malfunction
	Similar to flight reference card No. 24.

When reviewing these limits it should be borne in mind that any limits set should be wide enough to allow for:-

(a) Governor and throttle linkage hysteresis.

(b) Temperature effect on 'Null' position indication.

(c) Maximum production tolerances in the governor.

It should be assumed that the aircraft would be placed unserviceable if limits are exceeded.

In order to ensure as consistent governing as possible it is considered that 225 rotor rpm should be set accurately. As the rpm gauge is only marked in increments of 10 it is suggested that a line be painted on this gauge at 225 rpm.

5.2 Governor performance

5.2.1 Take-off and hover

The static rotor "droop" experienced during the initial stage of take-off with engine No. GA 632 fitted and which had been reported on other Wessex Mk. 3 helicopters is thought to be due in the main to the throttle/collective cam profile. This is borne out by the fact that in manual control, if the throttle is fixed, a similar static rotor "droop" takes place in the first few inches of collective movement on those aircraft that exhibit this tendency when governed.

This droop is not considered to be serious under normal temperature operating conditions provided it is no worse than has already been seen (i.e. 3 to 4 rotor rpm) because by the time the helicopter becomes light on its wheels in the take-off phase the rotor rpm have recovered to the nominal value. It is also thought that any attempt to modify the cam to bring about over-fuelling to counteract this for the take-off case, may prove an embarrassment in auto-rotation due to free turbine follow-up when making collective applications to control autorotative rpm.

/5.2.2

5.2.2 Climb at 60 knots IAS at 400 psi torque

Governing in the climb was generally satisfactory. Rotor "droop" experienced at 4,000 and 7,000 feet, although not embarrassing, is not understood. This characteristic has been seen in other Wessex Mk. 3 helicopters both at A&AEE and at the Firms. It is possible that this is once again a cam effect, but the shortage of time did not permit further investigation.

5.2.3 Level flight at 2,000 and 10,000 feet through the speed range

Governing during level flight was good, and consistent between the two engines tested and compared favourably with similar tests on XG 255 (Ref. 1).

5.2.4 Flight idle descent

In the descents carried out, the free turbine was well controlled throughout. It was evident however that the possibility of a governor being at the limit of its authority ('Null' indicator full right showing maximum governor fuel spill) was real at high altitudes during a descent. This however should not cause any difficulty as long as pilots are warned that this condition can occur.

5.2.5 Flight at varying power up to maximum torque

Governing during vertical flight was satisfactory and both the rotor rpm and 'Null' indication were within production clearance tolerances recommended by the Firm. A rotor droop of 3 to 4 rotor rpm at approximately 200 psi torque was seen when engine No. GA 632 was fitted, whilst with engine No. GA 3008 fitted this droop was insignificant. This droop is not always seen and when it is present, will vary between aircraft. As quoted in para. 5.2.1 it is considered not to be serious under normal temperate operating conditions. This characteristic will be investigated during tropical trials.

5.2.6 Engine response during recovery from autorotation

Engine response during recovery was very good. A maximum collective application time of 3 seconds quoted in aircrew notes would, from the result obtained during the trial, produce a negligible rotor "droop". In fact the test results compare favourably with those produced in Ref. 1.

5.3 Powered flight recovery from ground idle descent

A minor handling problem can be encountered in a powered recovery from an autorotative condition (engine ground idling) near the ground in that it is considered that a minimum height of 100 feet is required if a harsh engagement of the free wheel is to be avoided. Although the aircrew notes include instructions for carrying out practice autorotative landings which include taking out the flight idle stop and reducing power to ground idle, it is understood that the Navy are not intending to practice autorotative landings in the Wessex Mk. 3. However, assuming the policy may possibly change it is desirable to refer to this problem in the aircrew notes.

/A

A suggested wording to be incorporated in paragraph 19(b) (Part 3 chapter 2 of the Notes) is -

The twist grip should not be turned to the engine ground idle position unless a landing is intended in this condition. A rapid recovery to powered flight from this condition may involve a harsh engagement of the free wheel.

5.4 Manual throttle handling with governor disengaged

Manual throttle handling on the test aircraft, was generally similar to that obtained on XG 255 (Ref. 1) but rotor speed was slightly more difficult to control. This was probably due to the variation in cam profile in the collective/throttle controls which can occur between aircraft.

The Gnome/Wessex Mk. 3 throttle is noticeably more sensitive than the Wessex Mk. 1, but provided rotor rpm on all production aircraft can be controlled within ± 5 rpm (i.e. between 220-230) in manual control, it is still considered to be an adequate emergency system.

5.5 Re-engaging the governor in flight

No problems were encountered in re-engaging the governor in flight in this aircraft and the datum achieved at 228 rotor rpm gave a 'Null' indication within the limits of Zero to 1 division right as quoted in the flight reference cards. On landing the 'Null' indication/rotor rpm seen was very close to the governor setting selected prior to take-off. However with the reported variations between production governors it may not be possible in some cases to achieve a 'Null' position within the existing limits of Zero to 1 division right for a given rotor rpm of 228 and a review of all existing limits should be made (see para. 5.1).

6. Recommendations

Resulting from the tests the following recommendations are made:-

(a) The existing method of engaging the governor prior to take-off be retained.

(b) A line be painted on the rotor speed gauge at 225 rpm to assist accurate governor setting up.

(c) The Aircraft and Engine Firms should be invited to review the existing governor limitations laid down in the Aircrew Notes and Flight Reference Cards.

(d) Development should be hastened to improve the present governor hysteresis effects and to introduce a modification to eliminate temperature effect on the governor and 'Null' indication system.

(e) The Engine Firm should, during their present development flying seek an explanation for the rotor "droop" existing in some governors just prior to lift off, and the rotor "droop" seen during a climb at 4,000 and 7,000 feet.

/(f)

(f) A warning should be included in Aircrew Notes that it may be necessary to adjust the twist grip to avoid free turbine overspeeding, during flight idle descent at altitude.

(g) Aircrew Notes should be amended to include reference to the problem of recovery to powered flight from "ground idle" autorotation as referred to in paragraph 5.3.

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Ref. No.	Author	Title
1		Wessex HAS Mk. 1 XM 326 Handling Trials with Napier 453 authority Rotor Speed Governor 7th Part of Report No. AAEE/931
2	Flt. Lt. G. W. Smith, RAF and A. Wilson, AMI Mech E, AFRAeS	Wessex Mk. 3 XT 255 (Gazelle NGA 22) Preliminary Engine Handling Trials 2nd Part of Report No. AAEE/931/3

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Appendix I

Recommended Gazelle 165 Engine Setting Up Procedure

Setting the Null Position Indicator

1. Extend the minimum stop of the governor to obtain the range from maximum to 10° on the governor range cover.

2. Run the engine and switch on AC supplies.

3. Select 235 rotor rpm at 800 lb./hour fuel flow with the governor range lever in the maximum emergency position (at rear stop).

4. Adjust the sensitivity on the TRU to obtain three divisions left on the null position indicator.

5. Advance the governor range lever forward until the fuel flow is reduced to 620 lb./hour (i.e. 22½% governor spill)

6. Adjust the zero adjustment on the TRU until the null needle is at zero.

7. With the governor range lever maintained on its forward stop, open the twist grip and note that the pointer moves from 6 to 8 divisions right.

Setting the Governor Stop

1. At minimum pitch. Adjust the twist grip to give 227 rotor rpm.

2. Advance the governor range lever until a 50-100 compressor rpm drop is indicated.

3. Screw the stop to contact the lever.

4. With the governor engaged, adjust the twist grip and collective control to obtain 850 to 900 lb./hour fuel flow. With the null indicator at zero, rotor speed should be 227 rpm (adjustment on stop - 1 flat = 1 rotor rpm).

Setting maximum rotor speed

1. Run the engine to give 700 lb./hour fuel flow at 220 rotor rpm with the governor range lever in manual (at rear position).

2. Open twist grip to check maximum rotor rpm. This should be 240 ± 3 rotor rpm. Adjust if necessary on governor stop to obtain this figure.

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Appendix II

Governor Settings and Datum Shifts During Trial Sorties

Engine No. 632

Method of governor engagement (as laid down in Aircrew Notes) i.e. governor range lever forward to stop. Twist grip opened to give 225 rotor rpm with Null Position Indicator within 1 division of full left. Twist grip locked and retained in this position throughout the sortie. The information taken was as follows:-

(a) At minimum pitch on ground after engaging governor before take-off. (b) In the hover at 70 feet after take-off. (c) In the hover at 70 feet on completion of sortie.
(d) At minimum pitch on ground after landing.

The Null position indicator extreme left position was recorded before engaging governor under (a) and after taking readings at (d)(by moving the governor range lever to the rear)

	Pressure Altitude feet	OAT °C	Torque psi	Rotor rpm	Compressor rpm	Fuel Flow lb./hr.	Null Position Indicator Governor Inoperative Divisions	Null Position Indicator Governor Engaged Divisions
a	300	+8.5	100	225	16,240	460	2.3 Left	1.2 left
b	370	+8	350	226.5	18,340	900		0.3 Left
c	370	+8	330	226	18,150	850		0.2 Left
d	300	+8	90	223	15,990	450	3.0 Left	1.6 Left

Engine No. GA 3008

a	-60	+11	98	225	16,220	450	2.2 Left	1.9 Left
b	0	+11	300	226	18,180	890		0.4 Left
c	0	+11	350	226	17,600	855		0.7 Left
d	-60	+11	90	223	15,940	425	2.9 Left	2.2 Left

Engine No. GA 3008

a	0	+12	100	225	16,250	460	2.9 Left	1.9 Left
b	70	+12	335	226.5	18,450	350		0.1 Left
c	70	+10	320	226	18,250	825		0.2 Left
d	0	+10	97	224	15,970	450	3.0 Left	2.0 Left

Engine No. GA 3008

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
b	0	+11	300	226	18,180	890		0.4 Left
c	0	+11	350	226	17,600	855		0.7 Left
d	-60	+11	90	223	15,940	425	2.9 Left	2.2 Left

Further Settings and Evidence of Datum Shifts During Other Flying

	Pressure Altitude feet	OAT °C	Torque psi	Rotor rpm	Compressor rpm	Fuel Flow lb./hr.	Null Position Indicator Governor Inoperative Divisions	Null Position Indicator Governor Engaged Divisions
a		+10	92	225	16,000	450	3.0 Left	2.2 Left
b	+92	+10	290	226	18,000	760		0.4 Left
c	+92	+8	280	226	17,800	720		0.4 Left
d	+86	+8	92	224	15,940	450	3.0 Left	2.1 Left

a	-140	+17	100	224	16,200	450	2.7 Left	2.0 Left
b	-100	+17	300	227	18,120	770		0.3 Left
c	-100	+14	260	227	17,700	700		0.9 Left
d	-150	+14	92	223	15,940	450	2.8 Left	2.2 Left

a	-30	+16	99	224	16,150	460	2.0 Left	2.0 Left
b	+40	+14	330	227	18,330	820		0.7 Left
c	+40	+11	285	226	17,900	760		0.8 Left
d	-30	+11	99	223	15,960	460		2.0 Left

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
b	-100	+17	300	227	18,120	770		0.3 Left
c	-100	+14	260	227	17,700	700		0.9 Left
d	-150	+14	92	223	15,940	450	2.8 Left	2.2 Left

b	0	+11	300	226	18,180	890		0.4 Left
c	0	+11	350	226	17,600	855		0.7 Left
d	-60	+11	90	223	15,940	425	2.9 Left	2.2 Left

b	-100	+17	300	227	18,120	770		0.3 Left
c	-100	+14	260	227	17,700	700		0.9 Left
d	-150	+14	92	223	15,940	450	2.8 Left	2.2 Left

Engine No. GA 3008

a	0	+12	100	225	16,250	460	2.9 Left	1.9 Left
b	70	+12	335	226.5	18,450	850		0.1 Left
c	70	+10	320	226	18,250	825		0.2 Left
d	0	+10	97	224	15,970	450	3.0 Left	2.0 Left

a	-30	+16	99	224	16,150	460	2.0 Left	2.0 Left
b	+40	+14	330	227	18,330	820		0.7 Left
c	+40	+11	285	226	17,900	760		0.8 Left
d	-30	+11	99	223	15,960	460		2.0 Left

Engine No. GA 3008

a	+780	+10	111	225	16,400	480	2.2 Left	1.5 Left
b	+850	+10	300	226.5	18,150	770		0
c	+850	+10	290	226.5	18,000	760		0.2 Right
d	+780	+10	95	224.5	16,020	450	2.5 Left	1.2 Left

a	-445	+15	100	224	16,150	470	3.1 Left	2.7 Left
b	-360	+15	320	227	18,320	840		1.0 Left
c	-360	+12	280	227	17,900	830		1.0 left
d	-430	+12	95	223	15,940	460	2.9 Left	2.6 Left

Engine No. GA 3008

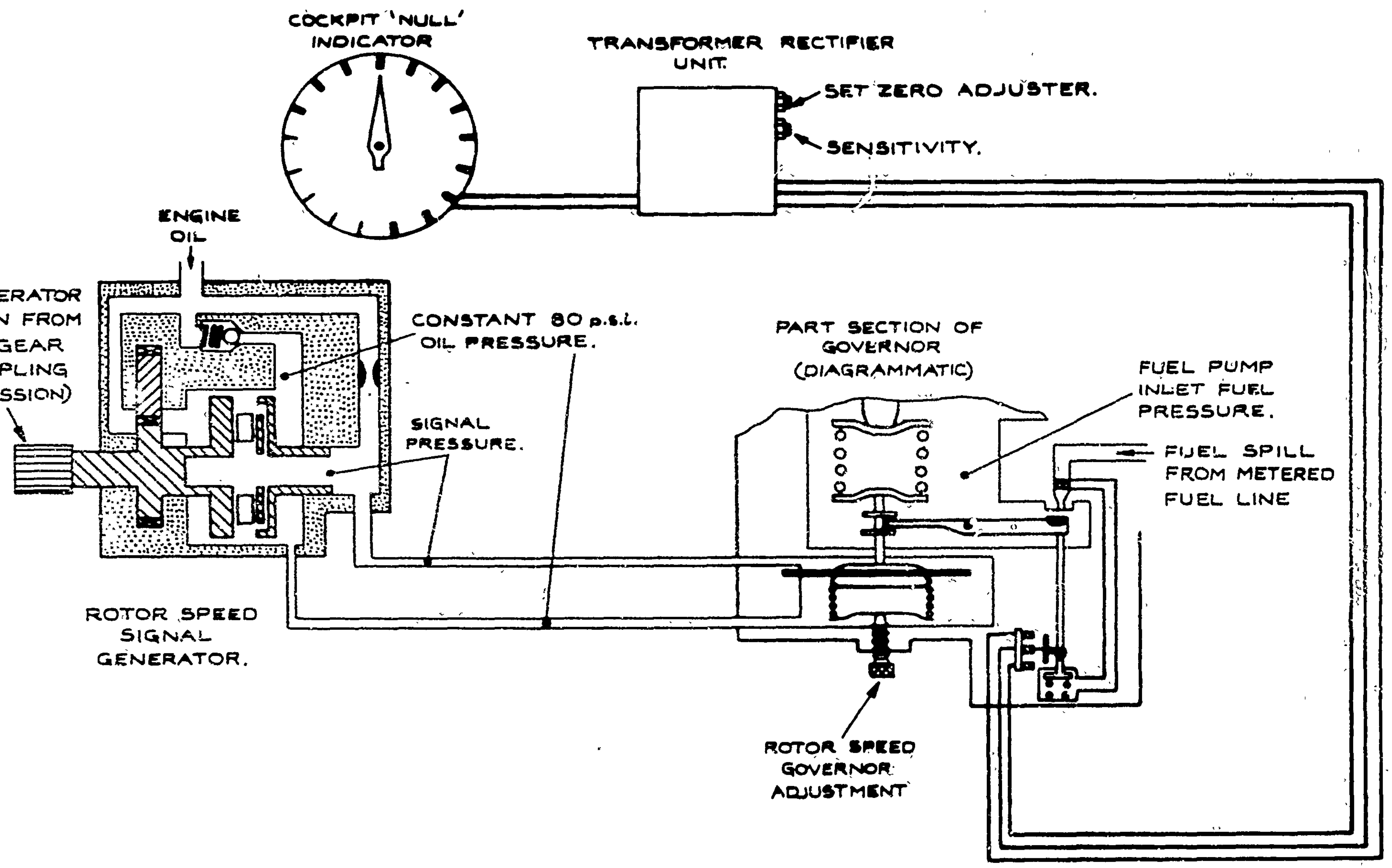
a	+520	+8	96	225	16,110	485	2.3 Left	1.7 Left
b	+590	+8	290	227	18,100	775		0.1 Left
c	+590	+8	290	227	18,000	760		0.1 Left
d	+520	+8	93	224	15,980	450	2.3 Left	1.6 Left

a	+250	+12	100	224	16,150	470	2.8 Left	1.8 Left
b	+300	+12	350	226	18,320	850		0
c	+300	+10	280	227	17,700	780		0
d	+200	+10	100	224	15,940	450	2.8 Left	2.0 Left

Engine No. GA 3008

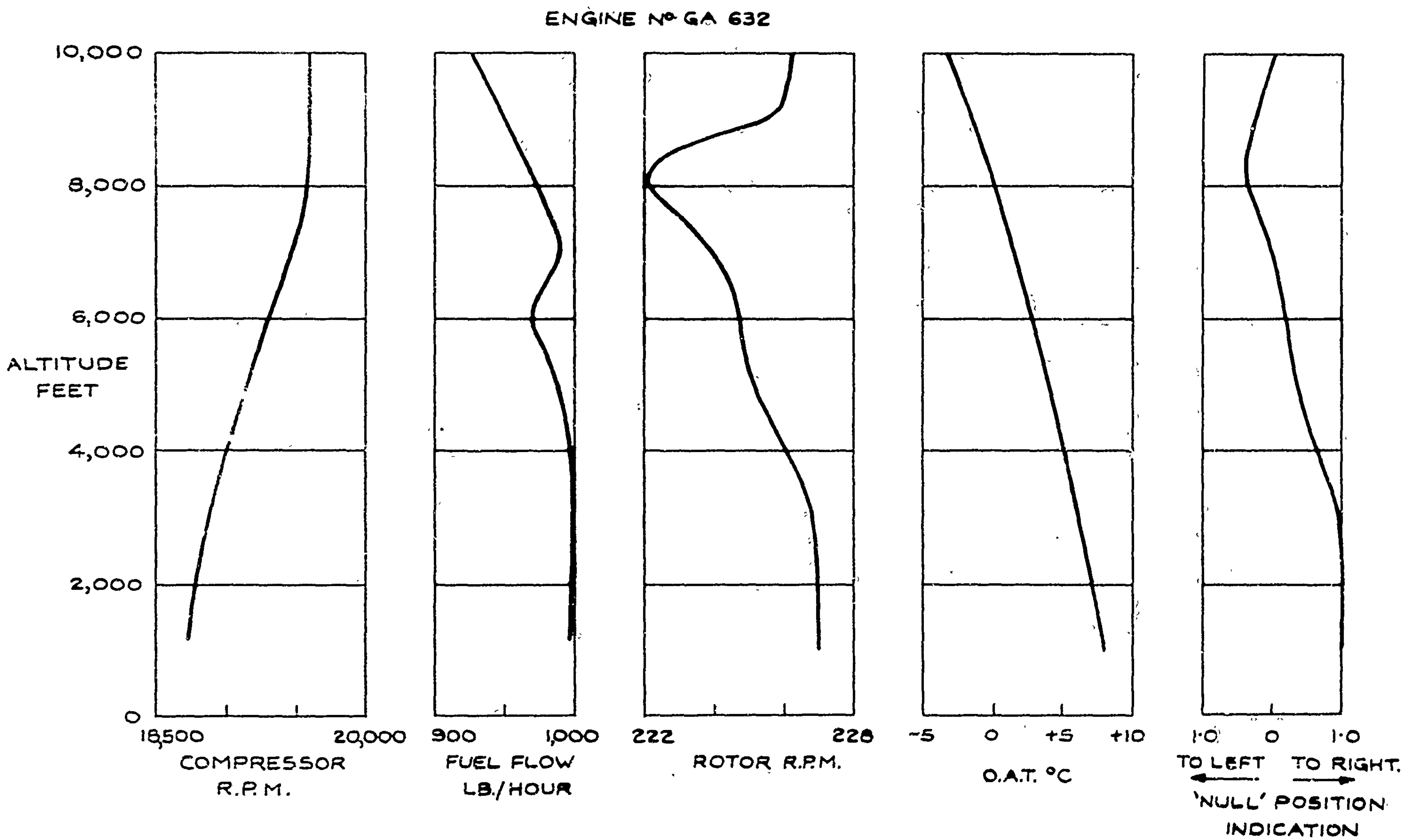
a	+200	+8	102	225	16,180	450	2.4 Left	2.0 Left
b	+270	+8	310	226.5	18,200	800		0.1 Left
c	+270	+8	290	226.5	18,000	750		0.2 Left
d	+200	+8	97	224.5	15,980	490	2.7 Left	1.1 Left

a	-40	+17	100	224	16,200	450	2.7 Left	2.0 Left
b	+20	+16	285	227	18,060	770		0.2 Left
c	+20	+16	270	227	17,860	700		0.2 Left
d	-40	+16	100	226	16,080	450	2.8 Left	1.7 Left



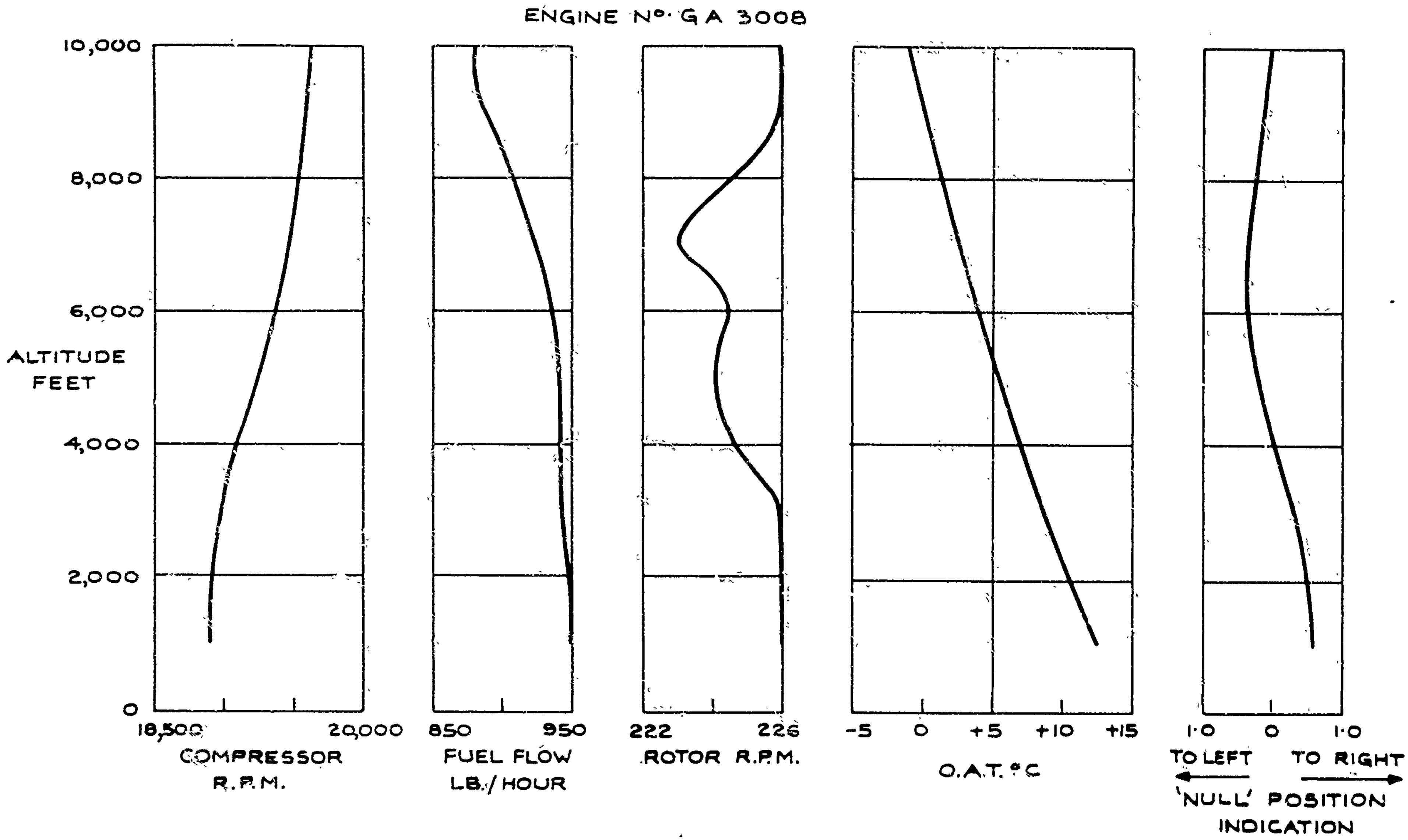
DIAGRAMMATIC LAYOUT OF ROTOR GOVERNOR & ROTOR SPEED SIGNAL GENERATOR.

FIG.1.



CLIMB TO 10,000 FEET AT 60 KNOTS I.A.S. & 400 P.S.I. TORQUE.

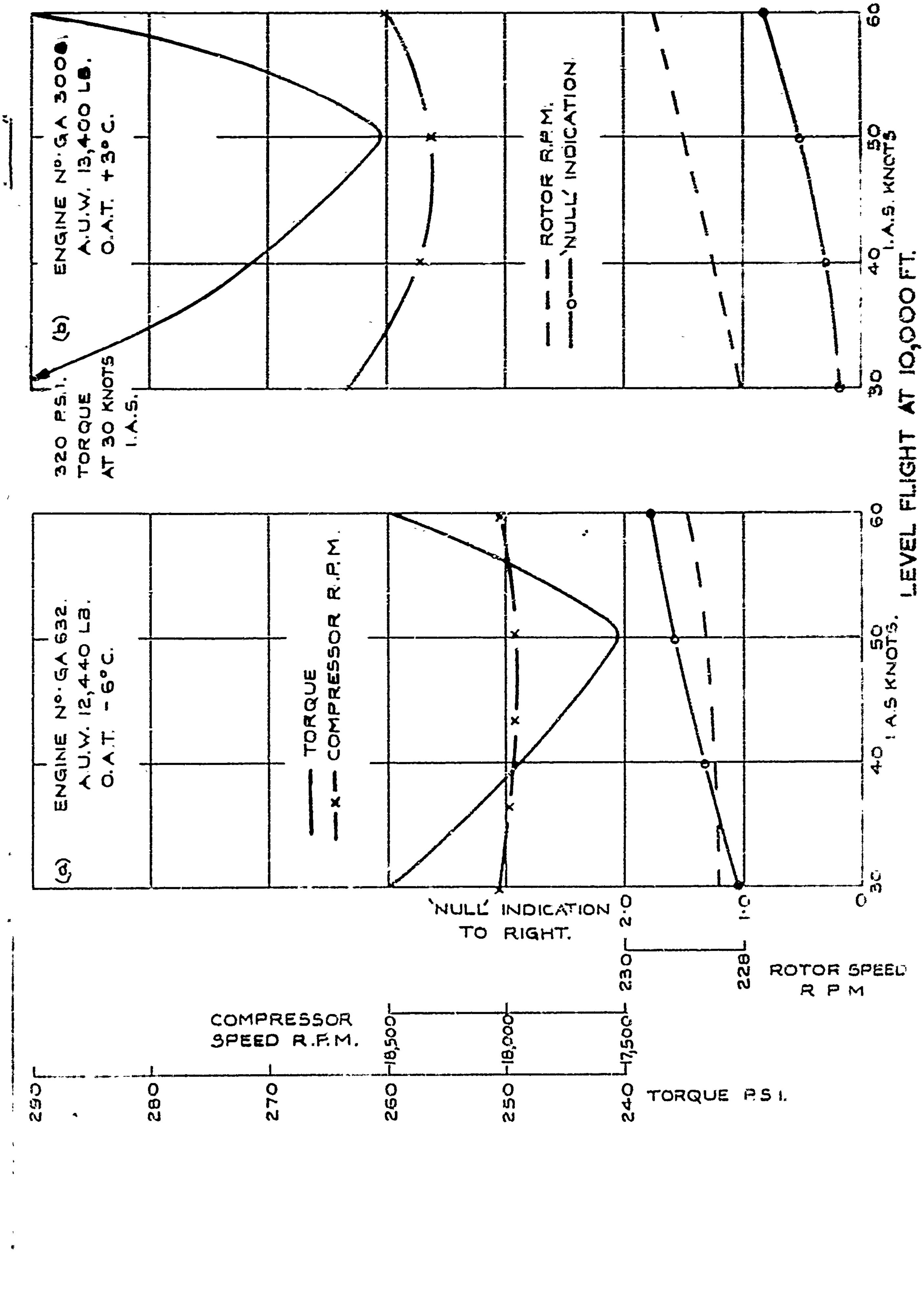
FIG.2.



CLIMB TO 10,000 FEET AT 60 KNOTS I.A.S. & 400 P.S.I. TORQUE.

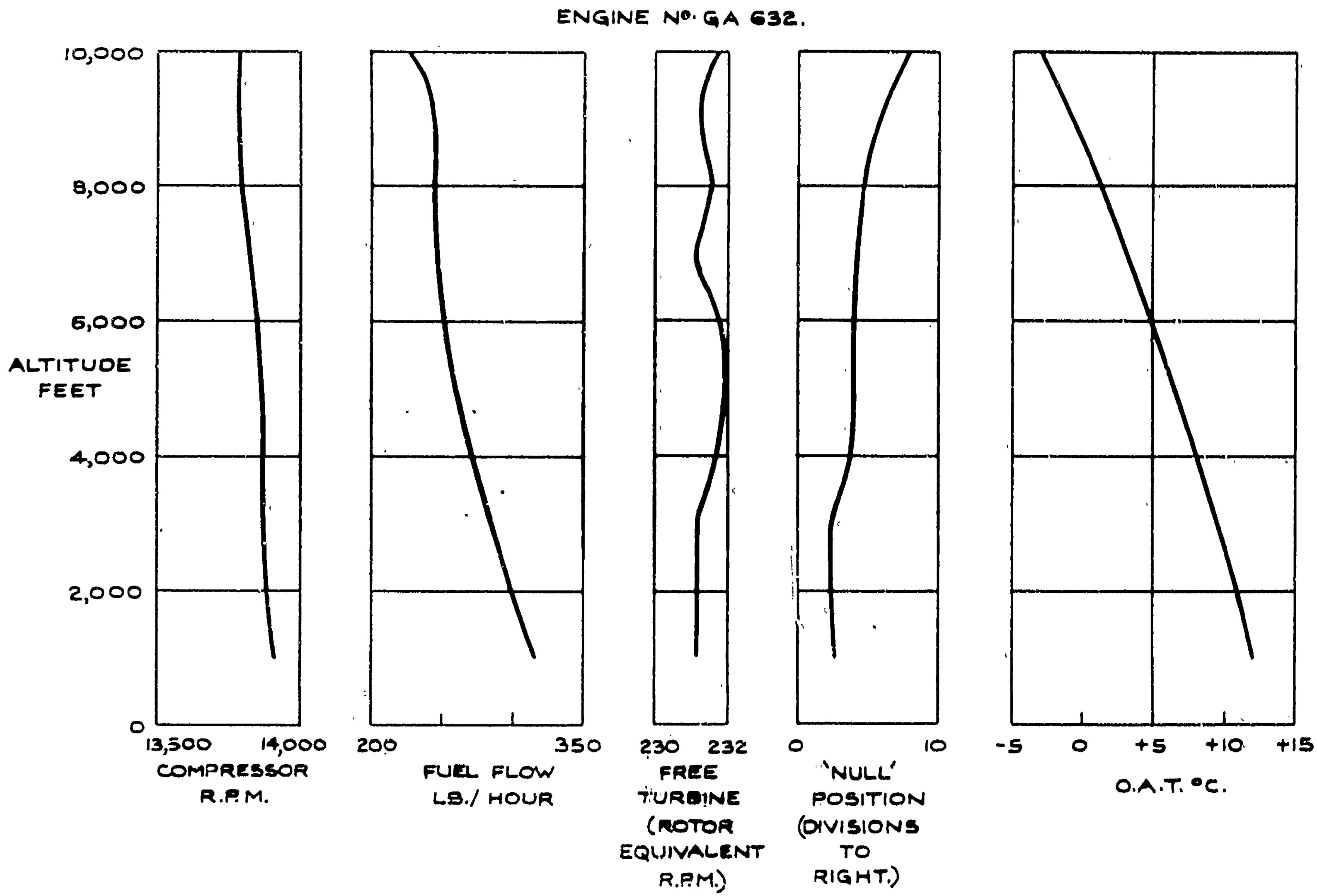
FIG 3.

FIG. 4.



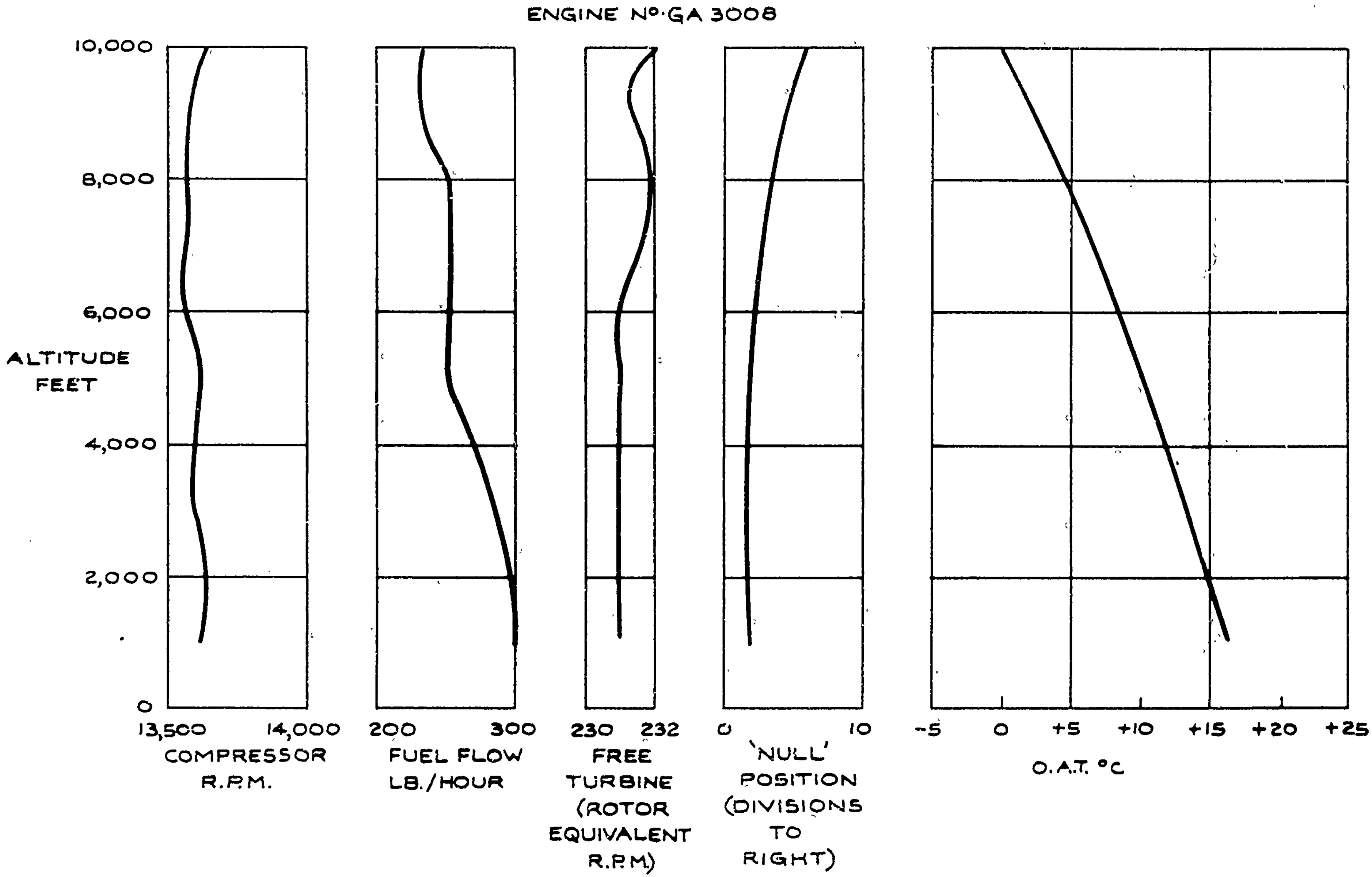
(a) ENGINE Nº GA 632.
A.U.W. 12,440 LB.
O.A.T. -6°C.
TORQUE
COMPRESSOR R.P.M.
(b) ENGINE Nº GA 3008.
A.U.W. 13,400 LB.
O.A.T. +3°C.
ROTOR R.P.M.
'NULL' INDICATION
320 P.S.I. TORQUE AT 30 KNOTS I.A.S.
'NULL' INDICATION TO RIGHT.
2·0
1·0
0
ROTOR SPEED R.P.M.
230
228
COMPRESSOR SPEED R.P.M.
18,500
18,000
17,500
TORQUE P.S.I.
290
280
270
260
250
240
30
40
50
60
I.A.S. KNOTS.
LEVEL FLIGHT AT 10,000 FT.

FIG.5.

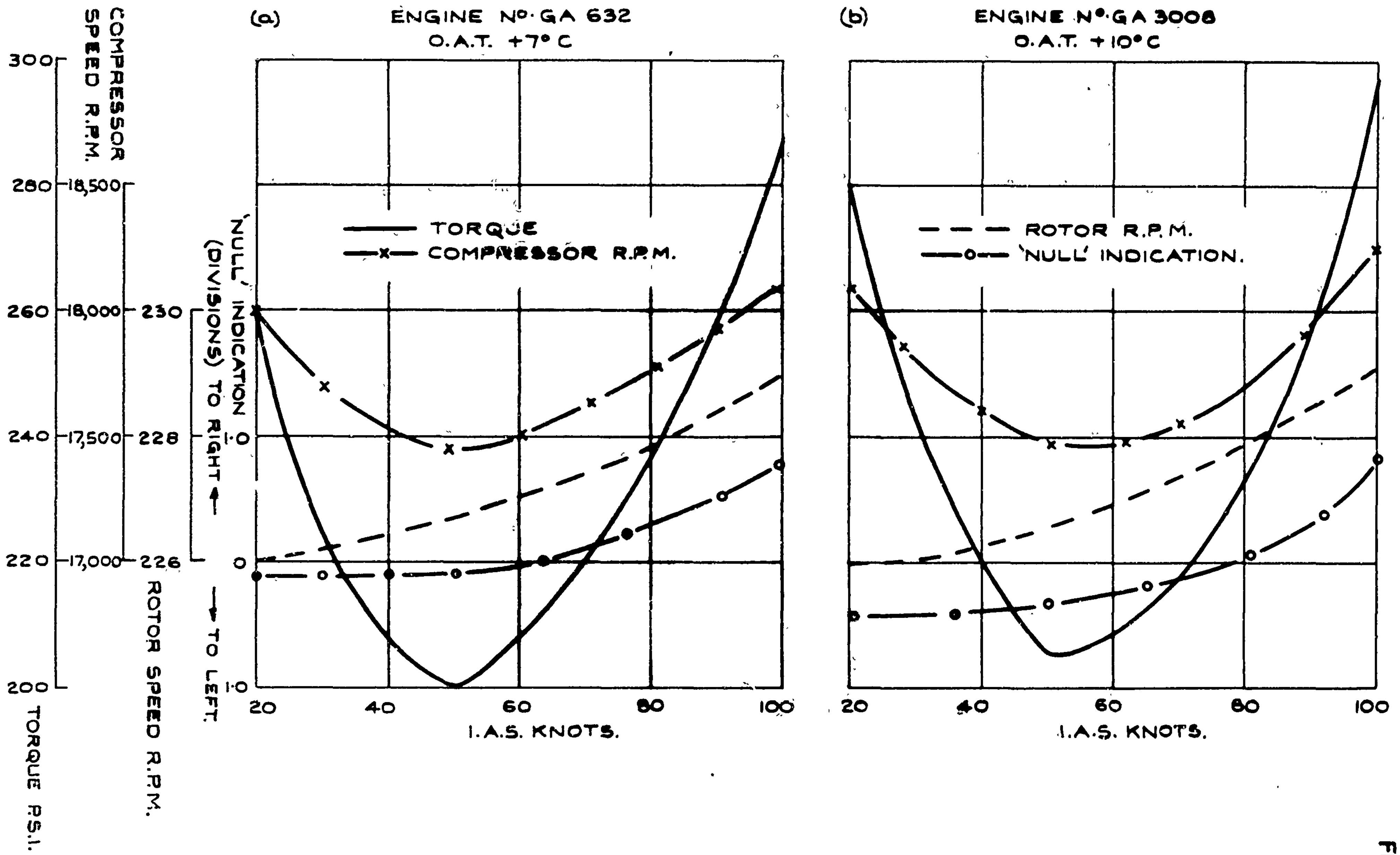


FLIGHT IDLE DESCENT FROM 10,000 FEET.

FIG. 6.

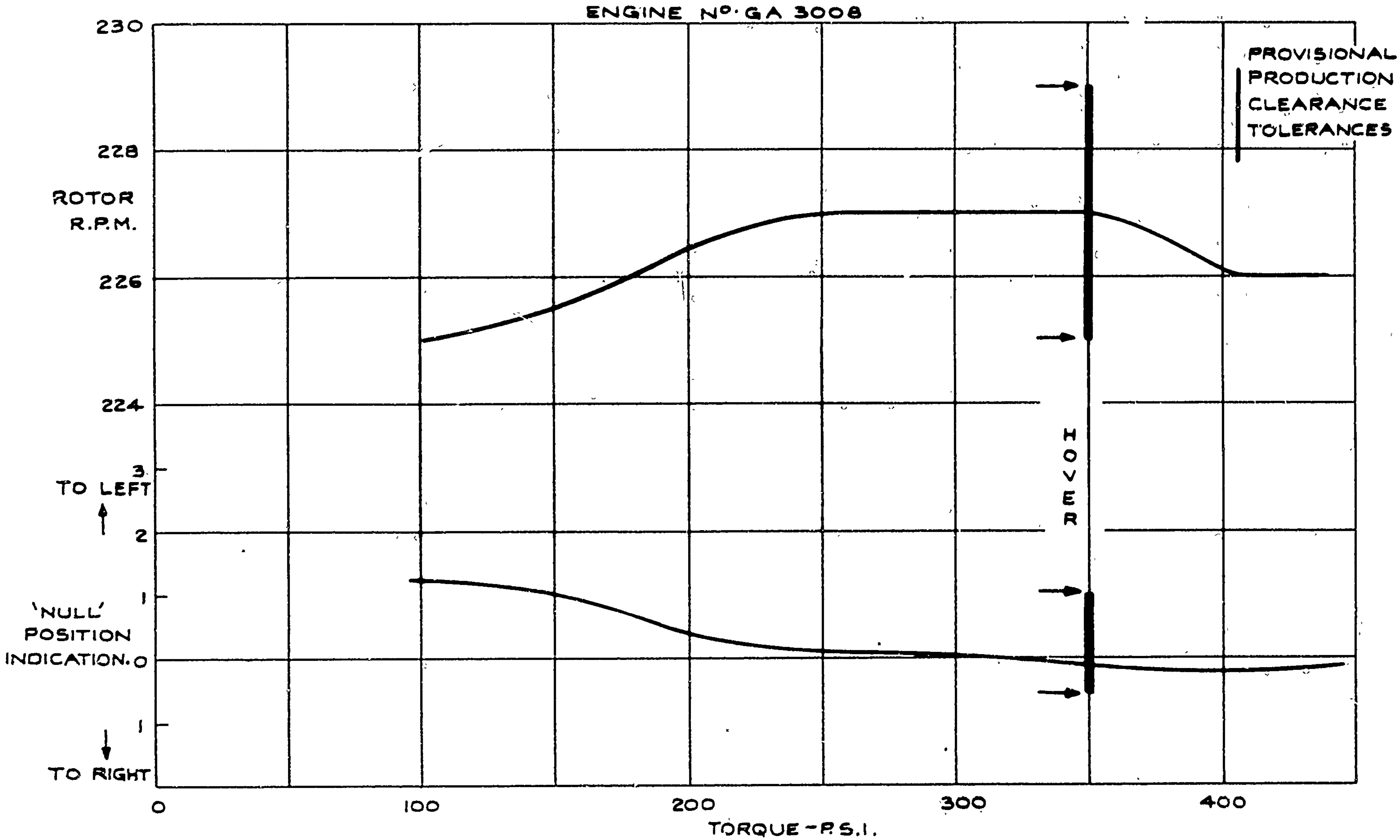


FLIGHT IDLE DESCENT FROM 10,000 FEET.



LEVEL FLIGHT THROUGH SPEED RANGE AT 2,000 FEET.

FIG. 7.



VARIATION OF 'NULL' INDICATOR READING & ROTOR SPEED WITH VARYING POWER
(GROUND & FLIGHT TESTS AT ZERO FORWARD SPEED)

FIG.8.

DETACHABLE ABSTRACT CARDS

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E. M. Evans and Sqn. Ldr. G. W. Smith, MBE, RAF

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Tests have been carried out on a production Wessex Mk. 3 XM 834, mainly to evaluate the characteristics of the production rotor speed governor and with particular reference to increased production tolerances in the system.

The results were satisfactory although datum shifts were experienced due to temperature, and governor and throttle control hysteresis effects. It is considered that these effects would not cause undue difficulty in controlling the engine and rotor, but some recommendations are made with a view to improving the governing system.

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